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QUARTERLY REVIEW

THE JOURNAL OF THE NATIONAL AGRICULTURAL ADVISORY SERVICE

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LONDON: HIS MAJESTY'S STATIONERY OFFICE: 1950

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ARTICLE

EXPERIMENTAL TECHNIQUES FOR THE EVALUATION OF SELECTIVE HERBICIDES

E. K. WOODFORD

Agricultural Research Council, Unit of Experimental Agronomy, Department of Agriculture, University of Oxford

The discovery that the growth-regulating substances were capable of controlling weeds in growing crops revolutionized thought and practice in weed control, and started a new interest in the methods of field evaluation. At first it was necessary to determine the effectiveness of such chemicals under as many different conditions as possible. Accurate methods of assessment were not required. Now that much of the preliminary observational work has been completed, it is essential to investigate the problems in greater detail and for this purpose more accurate and sensitive techniques are required. This article gives a general indication of the nature of the problems concerned, and of the principles that have to be borne in mind when planning field experiments of this type, and discusses the techniques that have been evolved at Oxford during the last few years. No attempt has been made, however, to describe the statistical methods of probit analysis that are often used.

It is comparatively easy to determine the toxicity of a herbicide to a single plant species. The evaluation of the selective toxicity where two or more species are growing in association is much more difficult and requires the use of experimental methods comparatively new to the agriculturist. In order to illustrate some of the difficulties that arise in such investigations, the data obtained from an experiment on the control of an annual weed growing in an annual crop are presented and discussed in the Appendix. These results bring out the fundamental fact that the evaluation of selective toxicity must always proceed in stages and that it is essential first to determine the toxicity of the herbicide *to the crop*, secondly, to the *weed* and thirdly, to the *crop and weed* in association. The third and final stage which has been illustrated by an example from an annual crop may raise other complications if it is concerned with perennial crops. In such experiments the yield of the crop has to be determined over many years, since the removal of weed species which were important when the experiment started, upsets the ecological balance, and may cause the invasion of other, perhaps more harmful, weeds in following years. It has been shown, for instance, that the amount of sodium chlorate required to kill ragwort in grassland also destroys some of the established grasses, and that the consequent opening up of the sward increases seedling ragwort establishment in the following year.

Field Trials

A discussion of the technique of carrying out field trials can conveniently be separated into two parts : first, the methods of herbicide application and plot layout, and secondly, the methods of assessing toxicity.

Method of Herbicide Application and Plot Layout

It is much easier to apply liquids evenly over a given area than dusts. For this reason herbicides are always used as liquid sprays of solutions or suspensions, unless it is desired to compare the effects of liquids and dusts, or to study the effect of the dust treatment.

Various machines have been devised for treating experimental plots, but for most small plot work a knapsack sprayer is perfectly adequate. It is easily cleaned and after a little experience the operator is able to put down a very even spray cover. For all our work, except that concerned with volume rates, knapsack sprayers are used and the amount of liquid applied is standardized at 100 gallons per acre.

Plot size is determined by the nature of the problem under investigation. If the toxicity of herbicides to weeds is being studied, then the size is determined by the evenness and density of the weed distribution. Normally plots of about 1/200th acre (12 feet $\times$ 18 feet) are used, but if the area of the weed infestation is small and it is desired to lay out a large number of plots, it is sometimes convenient to use plots as small as one square yard and to apply the herbicide from a small hand sprayer. When details of crop yields are required, the size of the plot is generally determined by the harvesting methods that are to be used. In our cereal yield experiments we generally use plots of about 1/100th acre and of a width that can conveniently be cut and harvested with a pusher combine.

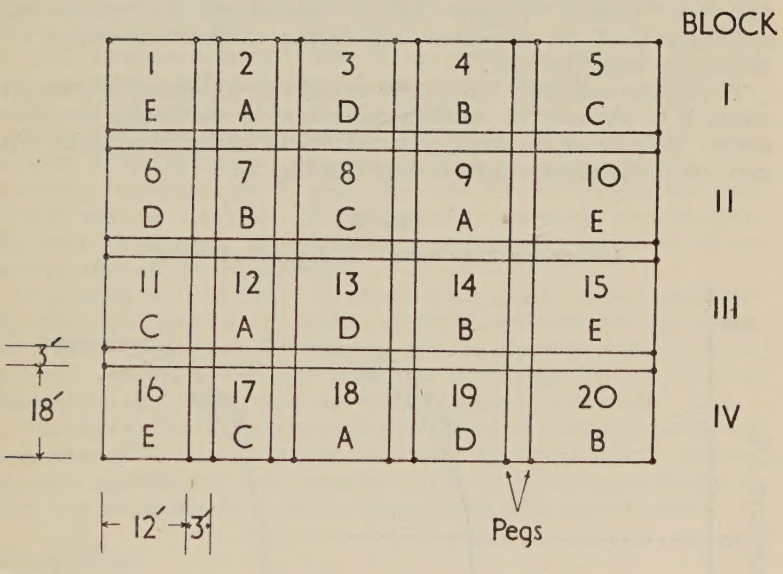
Because of the danger of spray or dust drift, it is essential to leave a wide path around each plot. We use a standard 3-ft. path irrespective of the size of the plot. This is convenient in the cereal yield experiments because the paths can be cut out prior to harvesting with a 3-ft. Autosythe. The plots are laid out with the aid of a " crosshead " and small wooden pegs are driven into the ground at the corners of each plot on the periphery of the experimental area. Before spraying or estimating plant density, the plots are outlined by connecting pegs on opposite sides of the experimental area with binder twine. The twine is usually removed after assessments have been made, but can be left in cereal yield experiments until after the paths have been cut out.

The method of laying out the plots is illustrated in Fig. 1 where 20 plots have been arranged in the form of a rectangle. The shape of the experimental area is determined by the distribution of the weed or weeds that are under investigation as well as the evenness and method of planting of the crop. The treatments to be applied to each plot are arranged at random within blocks. In the layout illustrated four blocks have been used and five treatments, including a control, have been randomized in each block. It is essential to have at least one

control plot in each block. In larger experiments where the blocks include more than 10 treatments and plant densities are required, it is frequently necessary to include two or more control plots. On the other hand, the number of replications in such experiments can often be reduced to three.

FIG. 1

Diagram showing Randomized Plot Layout with five plots 1/200th acre in each of four Blocks



TREATMENTS

Control	...	...	...	...	...	...	...	= A
MCPA 0.05 per cent	at	100 gal./acre	=	½	lb.	per	acre	= B
„ 0.10	„	„	„	=	1	„		= C
„ 0.20	„	„	„	=	2	„		= D
„ 0.40	„	„	„	=	4	„		= E

ASSESSMENT OF TOXICITY

Crop. The most useful criterion of response is crop yield and the methods of assessment and statistical analysis are the same as those used in fertilizer experiments. With growth-regulating substances, changes in the developmental morphology of the plant are sometimes more accurate estimates of effect than differences in yield. Flowering of linseed, for instance, is delayed by high doses of MCPA, and an estimation of this delay is often a more sensitive method of measuring toxicity than yield. Such compounds also cause abnormal flower and

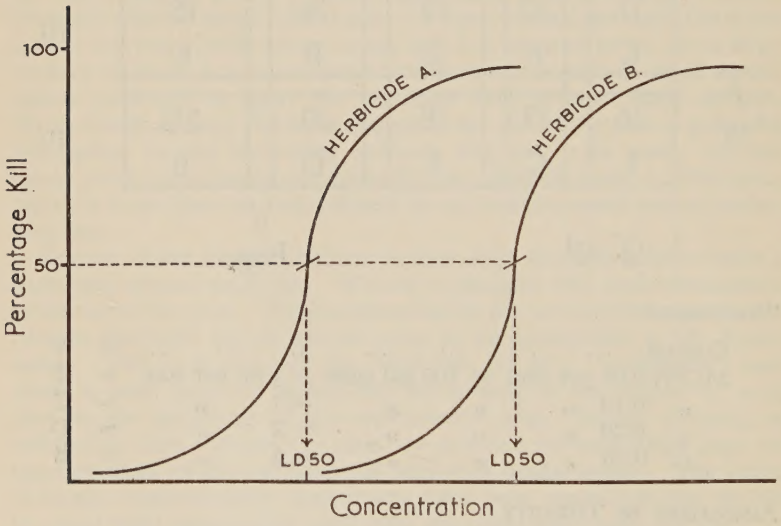
seed development and although these differences are difficult to measure quantitatively, it is important that they should be observed, as they are often indications of changes in crop quality.

Weeds. The methods of assessing the toxicity of herbicides to crops are concerned with small differences in yield or development and are designed to determine the amount of herbicides that can be applied without reducing yield. With weeds, the emphasis is on the amount of chemical required to kill the plant. Yield responses are " quantitative " and are measured by the methods evolved for cultural trials. Kill is a " quantal " response (all or nothing) and the experimental techniques used for assessment are similar to those developed for insecticides and fungicides.

To estimate accurately the toxicity of different substances to different weeds it is necessary to establish the nature of the dosage mortality curve. Because of the inherent variability of biological material this curve always assumes a sigmoid form (see Fig. 2).

FIG. 2

Dosage mortality curve. Substances A and B



In consequence, it is very difficult to determine the exact concentration or amount of herbicide required to kill all the plants. It is much more accurate to measure the concentration required to kill 50 per cent of the plants, a figure known as the L.D.50. The relative susceptibilities of different weed species to a herbicide or the relative toxicity of different herbicides to a weed, are therefore often expressed as the ratios of L.D.50 values. For instance, if the L.D.50 of 2,4 dinitro-6-secondary butyl phenol (DNBP) for yellow charlock was 0.05 per cent (equivalent

to ½-lb. per acre when applied at 100 gallons per acre), and the L.D.50 of the same substance to white charlock at the same stage of development was 0.10 per cent, then it could be stated that DNBP was twice as toxic to yellow charlock as to white charlock.

For practical purposes the concentration of herbicide required to kill 90-100 per cent of the plants is more useful. This concentration can be estimated from the dosage-mortality curves, but there are other methods of estimation and also of comparing relative toxicities over the whole range of kills which are much more accurate. These involve transformations of the data which change the sigmoid dosage-response curves into straight lines. Although it is not possible to discuss such methods in this article, it is important to realize that they do exist and that very often greatly increased accuracy can be obtained by using them.

The accuracy with which it is possible to estimate the number of weeds growing on the experimental plots depends on the density and evenness of distribution of the weed and on its growth habit. It is, therefore, very important to spend time and care in selecting the most suitable area for the trial. Different species are rarely distributed in the same manner and, in consequence, it is usually better to confine each experiment to a single weed.

In general, it is advisable to assess plant density before and after the spraying treatments are applied, in order to determine the percentage kill obtained. However, if the weed stand is extremely uniform, post-spraying counts are sufficient, since the percentage kill can then be obtained by comparison with the density on the control plots.

It is often difficult to count individual plants of perennial weeds and even more difficult to determine when they have been killed ; in consequence experiments with perennial weeds are much more difficult to carry out accurately than similar experiments with annual weeds.

Annual Weeds

The type of crop in which the weed is growing is not of particular importance, provided that it does not shield the weed. After the plots have been laid out in the manner described earlier in this article, the weeds in each plot are estimated by the quadrat method. The size of quadrat to use depends upon the density and size of the weeds. We find that 6-in., 12-in. and metre sizes are sufficient for most requirements. The number of random quadrats to throw per plot depends upon the evenness and density of the weed population. With plots of about 1/200th acre, it is usually necessary to count about 200 plants per plot.

Similar counts are made as soon as the herbicide has completed its action, and the percentage kills calculated for each concentration. From these figures the dosage-mortality curve is plotted and the concentrations required to kill either 50 or 90 per cent of the weeds determined.

The time allowed between pre- and post-spraying counts will depend upon the type of herbicide used. The " contact " herbicides, such as sulphuric acid, cupric chloride, and dinitro compounds (DNOC, DNBP),

are much more rapid in their action than the growth-regulating substances. With the former, we usually allow two to three weeks; with the latter about a month. The time interval, however, should be kept as short as possible so as to eliminate the complicating factor that is introduced by the germination of weed seeds after the treatment has been applied.

Perennial Weeds

Theoretically, the procedure employed for annual weeds can be used for perennials. Pre- and post-spraying counts are made and the percentage kills estimated. But, as has been indicated, there are many other difficulties due to the growth habits of the plant and the difficulty of assessing kill. The growth-regulating substances act very slowly and take many months to kill perennial weeds. For this reason the final weed counts should not be made until at least nine months after the treatment. This adds further complications, since the weed population changes during the interval and it becomes impossible, without very detailed study, to determine which of the plants or shoots counted finally are the same as those that were treated. Perennial weeds that seed readily and spread vegetatively underground are the most difficult to deal with.

Often after the application of a herbicide, young shoots regenerate from older plants that have been killed back by the treatment and are indistinguishable from seedlings. The only accurate method of determining the number of plants the treatment has killed is to mark the plants counted at the time of the treatment. This is obviously impossible in routine experiments. It can be overcome, partially, by making more frequent counts of the seedling, rosette and flowering plants.

In our experiments with perennials that do not regenerate readily from seed, such as creeping thistle, we rely on pre- and post-spraying counts of plant shoots. If seedling regeneration is important, as with ragwort, we make more frequent counts and distinguish between seedlings, rosettes and flowering shoots in the pre-spraying assessment, and seedlings, regenerating shoots and rosettes, in the post-spraying assessment.

Crop and Weeds

Experiments which are concerned with crop and weeds growing in association are carried out in much the same way as experiments on crop and weed separately.

The methods already described for assessing toxicity to crop and weeds can also be used for assessing toxicity to both types of plants when growing in association. The experiment described in the Appendix is a good example of the sort of results that are obtained. As has been explained, it is difficult to generalize from such experiments unless the toxicity of the herbicide to crop and weeds is already known. The usual object of such experiments is to demonstrate the economic possibilities of herbicides that have been selected as promising from the results of preliminary work. However, in the evaluation of herbicides for the

control of weeds in perennial crops, this type of experiment also supplies essential basic information on the manner in which the crop reacts to the removal of the weeds. For instance, it is not much use killing the weeds in a pasture if nothing better takes their place.

Accurate experiments to evaluate the selective toxicity of herbicides to perennial weeds growing in a perennial crop are probably the most difficult of all to carry out satisfactorily. They are, however, the type of experiment which is, at the present time, likely to give the most useful practical information. Preliminary work has already shown that growth-regulating substances will control many perennial weeds of grassland and that the concentrations required are relatively non-toxic to mature grasses and clovers. It is now necessary to determine the long-term effects of such treatments when used in conjunction with good grassland husbandry.

Conclusions

It is impossible, in a short discussion of this type, to present all the detailed information that is required for the design, execution and analysis of weed-control experiments. An attempt has been made to illustrate some of the important principles which are basic to this type of investigation, so that an experimenter new to the field can appreciate some of the difficulties that he may encounter, as well as some of the methods that have been designed for overcoming them. It may be considered that the types of experiments that have been discussed are too elaborate for officers who, of necessity, often have to carry them out in their spare time. If this is so, then it would probably be better not to carry out any experiments at all. Trials which are based on visual methods of assessment may be useful for obtaining indications which are later to be checked by accurate experimentation, but when used alone are often misleading and dangerous.

All the selective herbicides that have so far been discovered are toxic to crops as well as weeds and are effective only if used within a particular dosage range. The optimum dosage varies with the crop variety and the weed species present. In consequence, it is necessary to carry out toxicity experiments on crops and weeds separately before attempting to evaluate selective toxicity to the weed growing with the crop. This aspect of the problem has been stressed in the techniques described above. It must also be remembered that many other factors, such as the stage of development and growth-rate of both crops and weeds, the methods of treatment application, and the climatic and soil environments, also influence toxicity and selective toxicity, and that their effects have to be studied before it is possible to make generalizations concerning the efficiency of a herbicide.

APPENDIX

A Weed Control Experiment in Peas

This experiment was designed to compare the relative toxicity of 2,4-dinitro 6-secondary butyl phenol (DNBP) and its ammonium

salt (NH_4DNBP) when sprayed on peas (Variety Harrison's Glory) which had 4-5 expanded leaves and were 2½-4 inches high. The experiment consisted of 56 plots arranged in a randomized block design. In addition to the sprayed plots, control plots (some clean weeded by hand and others unweeded), were included. Treatment effects were determined by estimating, for each plot, the yield of peas and the percentage kill of the dominant weed (*Stellaria media*).

The results are presented in tabular and graphical form. From the table it will be seen that 0.6 per cent DNBP and 0.38 per cent NH_4DNBP killed 91 per cent of the chickweed present. It can be

Table

Treatment		Yield of Threshed Peas	Percentage Reduction Compared with the Hand Weeded	Yield as percentage of Control	*Stellaria media* percentage Kill
	per cent	*cwt. per acre*			
DNBP	0.10	10.3	24	121	11.6
	0.16	10.9	20	129	31.3
	0.24	12.0	12	141	64.6
	0.38	12.6	7	148	76.6
	0.60	11.8	13	139	91.2
Mean		11.5			
NH_4DNBP	0.10	9.8	28	116	16.3
	0.16	10.3	24	121	43.0
	0.24	10.4	23	123	70.1
	0.38	9.8	28	116	91.1
	0.60	6.0	56	71	95.9
Mean		9.3			
Clean Weeded		13.6	—	161	
Control		8.5	37	—	
S.D. (p=0.05)					
Between treatments		3.1			
Between 1 treatment and control		2.7	Coefficient of Variation=20.7 per cent		
or 1 treatment and clean weeded		2.7			

Peas: 2½-3½-4 inches with 4-5 expanded leaves.
Stellaria media branched plants 1½-2 inches across.

concluded, therefore, that NH_4DNBP was about one-and-a-half times as effective as DNBP for the control of this weed at the particular stage of development at which it was present (Branched plants 1½-2 inches across). The efficiency of the chemicals as selective weedkillers, however, depends upon their relative toxicity to weeds and crop and, in

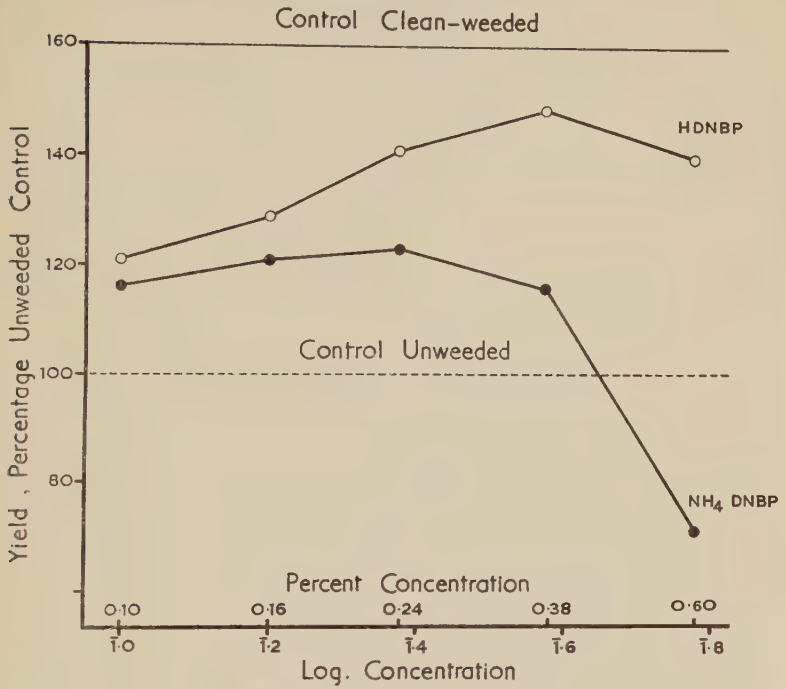
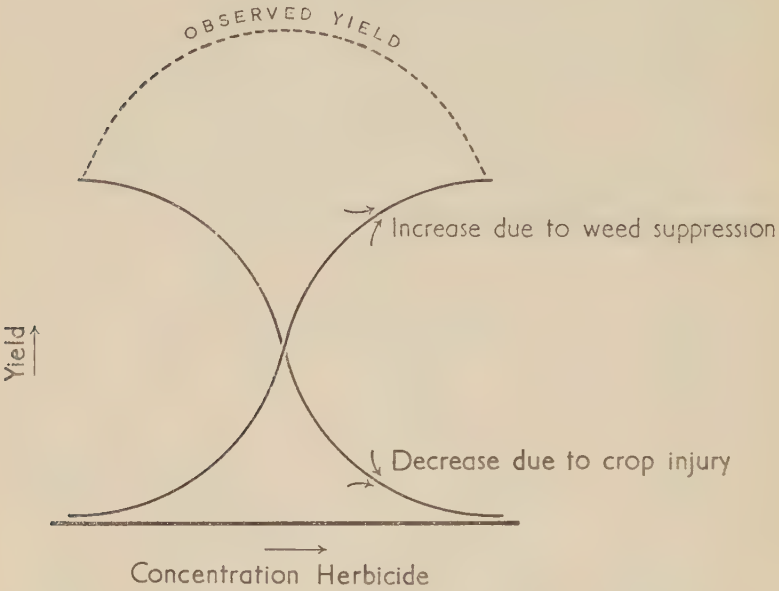


Fig. 3. *Weed Control in Peas*

order to obtain an understanding of this, it is also necessary to consider the crop yield results. The graph (see Fig. 3) shows the yields obtained from each treatment expressed as a percentage of the unweeded control plots (100). It will be seen that the clean weeded plots gave a yield increase of 60 per cent and that the increases from the individual treatments varied with the amount or concentration of chemical applied. Maximum yields were obtained from the plots treated with DNBP, but the concentration of this substance required to produce the highest yield (0.38 per cent) was higher than that required for NH_4DNBP (0.24 per cent). It is obvious, therefore, that NH_4DNBP is less efficient as a selective killer of chickweed than DNBP, although it is more toxic to both crop and weed. From these curves it is, however, impossible to determine the true toxicity of the herbicide to the crop because the yield curves are dependent upon the two counter-acting effects of the chemical, i.e., toxicity to weeds and toxicity to crop. The efficiency of the chemicals as weed killers increases with increasing dosages, but when a certain limiting concentration is reached, they also become toxic to the crop. This is shown diagramatically in Fig. 4, where it is assumed that reduction in weed stand causes a proportionate increase in crop yield.

Fig. 4.



The broken line represents the yield results that are likely to be obtained in field trials of this type and is due to the interaction of the two factors.

The complete interpretation of the results obtained in this experiment is impossible unless the effects of the chemicals on weed and crop are determined separately.

COMMONWEALTH AGRICULTURAL BUREAUX PUBLICATIONS

The Establishment of Vegetation on Industrial Waste Land. R. O. Whyte and J. W. B. Sisam. 1950. 10s.

This publication is the ultimate outcome of a study of the problems and techniques of reclamation of industrial waste land by the study of vegetation. Most of the information has been collected from unpublished sources from those who have undertaken the work or are interested in its execution.

Field Trials : Part II. Analysis of Covariance. J. Wishart. 3s. 6d.

Written by the author of *Field Trials : Their Layout and Statistical Analysis*, published in 1940 and since reprinted, the present bulletin carries the subject into the domain of those topics which are commonly referred to as comprising *Analysis of Covariance*. The object is to assist the investigator still further in reducing his experimental errors, by pointing out how observations made on variates, other than those in which he is specifically interested, may be used by means of a special arithmetical technique in the statistical analysis of his results.

ABSTRACTS

ANIMAL BREEDING

The Relation of Pedigree Promise to Performance of Proved Holstein-Friesian Bulls. ELDRIDGE, F. E. and SALISBURY, G. W. *J. Dairy Sci.*, 1949, **32**, 10.

The progeny test is regarded as the most accurate method of estimating the production of future daughters of a sire. The purpose of this study is to try to determine the value of an unproved bull by using the production performances of his ancestors, collateral females, together with the production of the cows to which he is mated.

Two groups were selected from the 1,451 Holstein-Friesian bulls proved under the D.H.I.A. records in New York. The first group consisted of 158 proven bulls (average number of daughter-dam comparisons 8.40), each of which had the following information available : his sire was proven (daughter-dam comparisons 21.05), the dam of the bull had at least one record (average number 4.64), the dam of the bull had at least one daughter with a record (average number 1.85).

The second group of 141 bulls were proven (average number of daughter-dam comparisons 8.13). All of these had the following information available : proof of his sire (daughter-dam comparisons 21.81), the dam of the bull had at least one record (average number 4.33), the dam of the bull was by a proven sire (average number daughter-dam comparisons 18.07).

Of 207 bulls meeting either set of criteria, 92 satisfied both, so were included in both groups.

It was found that the correlation between the direct pedigree estimate and the actual production of the daughters of the bull was fairly small (+ 0.37) and accounted for 14 per cent of the variation between daughter and dam in terms of butterfat yield.

When information of the production yield of the cows to which the bulls were mated was added, the correlation was increased to +0.7 and accounted for 47.5-49 per cent of the variation.

This study showed that in the selection of young dairy bulls the record of performance of the females in their pedigrees are of importance in the following order : (*a*) the average production of the paternal half-sisters of the bull ; (*b*) the average production of the dams of the paternal half-sisters of the bull ; (*c*) the average production of the paternal half-sisters of the bull's dam.

The production of the dams of the bulls or of his maternal half-sisters showed no relationship to the production of the daughters. It should, however, be borne in mind that the dams of the bulls included in this study were a very highly selected group, and had an average butterfat production of from 30-80 lb. over the other females in the study. It may be considered that where the average production of the dams is

over 450 lb. of butter fat, individual differences between dams is of little significance.

Welsh Mountain Ewes as a Source of Grassland Breeding Ewes. Wilkinson, J. H. S., *Journal R.A.S.E.*, 1949, **110.**

Trials were started on the Cambridge University Farm in the autumn of 1944 with a view to finding a grassland ewe as an alternative to the well tried and rather expensive half-bred. It was considered that if the Welsh ewe was successful as the parent stock then a much less costly ewe could be produced.

Welsh ewes were crossed with Border Leicester and Dorset Horn rams and the progeny from these crosses were subsequently kept for breeding.

The draft Welsh ewes in themselves have proved successful as breeders, though their management has been difficult on account of their wandering instinct. It was, however, found that those purchased in the years 1944-46 inclusive appreciated in value after rearing two crops of lambs.

The Border Leicester × Welsh ewes proved the better of the two crosses ; they were more prolific, and produced a greater weight of live lamb up to eighteen weeks of age. Although this difference was not large, it was consistent over the three years. These ewes also suffered fewer losses at lambing time and needed less shepherding.

Both the Border Leicester and Dorset crosses mated well with the Suffolk ram either for fat lamb production or for producing yet another very good second cross breeding ewe. From the experiences gained in these trials it would seem possible to maintain a breeding flock of 250 breeding ewes by buying in 50 regular draft Welsh Mountain ewes every second year, and keeping ewe lambs of the Border Leicester × Welsh and Suffolk × Border Leicester Welsh as breeding ewes.

W.L.

DAIRY HUSBANDRY

Milking Technique

According to the recent farm machinery census, there are now about 70,000 milking machines on farms in England and Wales, probably about three times as many as before the war. It is therefore not surprising that interest in machine milking technique is sustained. Apart from questions of milking speed which effected labour economy, and of completeness of milking which affects immediate output, it is now fairly widely accepted that milking management can also affect the incidence of mastitis. Some further information on all of these aspects has recently been published by the National Institute for Research in Dairying.

Dodd, Foot and Henriques (*J. Dairy Res.* 1949, **16,** 301) in further studies of the effect of udder washing on subsequent machine milking, point out that in investigations of this type it is necessary to differentiate between the inherent effect of an established washing routine on the

let-down of milk and its effect when introduced temporarily to cows used to some other routine. Thus, where cows were accustomed to udder washing one minute before milking, the delaying of milking till six minutes after washing at any *one milking* resulted in a slightly slower rate of milking and a reduced yield of milk and butterfat. As opposed to these temporary effects, another experiment is reported which provides some evidence that an established routine of washing one minute before milking is to be preferred to washing twenty minutes before milking in so far as completeness of milking is concerned. In this work the amount of milk and butterfat left in the udder after a particular milking was estimated by carrying out a further milking by hand following an injection of oxytocin. This method of estimating residual milk is thought to be a useful way of assessing efficiency of milking.

These studies and others reported earlier by the same workers were carried out over periods of a few weeks only. It might be argued that a longer period is required to accustom cows to an udder washing and milking routine and that the effect of a previously established routine might carry over to obscure a routine used for a short period. A further experiment was therefore carried out by Dodd, Foot, Henriques and Neave (*J. Dairy Res.* 1950, **17,** in press) in which 38 first-calf heifers at four research centres were paired before calving and one member of each pair allocated by lot to a four-minute milking routine, and the other in each pair to an eight-minute milking routine. For every milking throughout the whole lactation the teat cups were kept on each heifer for the four minutes or eight minutes, irrespective of the amount of milk in the udder at the end of the particular period and in spite of cessation of milk flow before the end of the four or eight minutes. About half of the four-minute heifers were found to be incompletely milked in early lactation and the machines were generally left on the eight-minute heifers after milk had ceased to flow. In spite of this there was no major effect on the rate of milking in the two groups. It was perhaps a little surprising that no significant difference appeared between the 305-day lactation yields of the two groups.

Rate of Milk Flow

Some interesting findings concerning the factors affecting rate of milk flow in machine milking have also been published by Baxter, Clark, Dodd and Foot (*J. Dairy Res.* 1950, **17,** in press). The hind-quarters of four cows were milked by normal teat cup and by teat canula at three levels of vacuum, the various treatments being imposed according to a time-table planned to allow statistical analyses of the results. It was found that the rate of flow for the eight quarters varied considerably when they were milked by teat cup but were almost constant when the canula was used. This suggested that the teat orifice is a very important factor controlling the rate of milking. With both teat cup and canula the maximum rate of milking increased with a rise in vacuum from 10.6 in. Hg. to 20.4 in. Hg. On the other hand, in the case of teat cup milking the amount of strippings tended to increase at the higher level

of vacuum due apparently to blockage in the teat. This experiment adds further evidence to the contention that, in practice, rate of milking is, to a major extent, controlled by physical factors at the teat orifice.

Effect of Mastitis Infection on Yield

There is, unfortunately, little precise evidence on the effect of mastitis infections on the yield of milk. The effect on yield of an infection in one quarter is usually hidden owing to the bulking of milk from the four quarters. By periodic routine milking with a machine specially constructed to collect milk from individual quarters, the immediate and long-term effect of mastitis on yield can be studied. Some results of investigations of this type are reported by Crossman, Dodd, Lee and Neave (*J. Dairy Res.* 1950, **17,** in press). Much of the data will require careful statistical analysis before a full appraisal of the effect of mastitis in its various forms can be made. This preliminary communication, however, gives examples of the effect not only of clinical infections but of sub-clinical infections also. The latter are shown in some cases to have no effect on the proportionate yield and in others to bring about a gradual reduction in yield in the infected quarter. Where penicillin was used to treat clinical cases, recovery in yield of a quarter often awaited the next lactation when recovery was in some cases complete. Here again, there was a great variation from cow to cow and a study of the frequency of different effects in different herds should be of great practical interest.

Chemical Quality of Milk

Since the publication of the last reference to this subject (*N.A.A.S. Quarterly Review No.* 6, *Winter*, 1949, 78-9), additional evidence indicating the deterioration of the chemical quality of milk has been published. A. L. Provan (*Int. Dairy Congr.* 1949, **2,** 217-26), states that the solids-not-fat content of milk dispatched from United Dairies creameries in Cheshire, Shropshire, Staffordshire and Derbyshire, has decreased from 8.9 per cent in 1923 to approximately 8.6 per cent in 1946, although the butterfat content altered comparatively little. An analysis of four years' data from M.M.B. creameries shows that when creamery bulk milk had an average S.N.F. content between 8.50 and 8.54 per cent the probable number of consignments below 8.50 per cent S.N.F. was 42 per cent. From monthly tests on 4,600 farms it was shown that the dispersion of individual S.N.F. values from the average at any particular level of butterfat was so wide that the butterfat test cannot be a true index to the S.N.F. content of milk from individual herds.

Data concerning the compositional quality of milk is presented in the 1949 *Report of the National Institute for Research in Dairying*, Shinfield, Reading. An example is given (pp. 42-3) of a commercial dairy herd in which the average fat content of the milk was considerably depressed for a long period when grazing a young ryegrass-clover ley in the spring. The provision of a daily supplement of 6-8 lb. of hay per cow increased the fat content of the milk from 1.84 to 2.37 per cent in three days, and

to 2.75 in thirteen days, whereas a similar group without hay remained at values between 1.69 and 1.89 per cent. When both groups of animals were transferred to a third year ley without hay, the fat contents improved to normal levels. It is suggested that an adequate intake of roughage plays some part in the depression although other undefined factors are also involved.

A report on oestrogens in grass and their possible effect on milk secretion is also given (p. 26). In 1949 measurable oestrogenic activity was found in perennial ryegrass, H.I. ryegrass, cocksfoot and broad red clover, but not in timothy, creeping fog, white clover and lucerne. In the grasses a high concentration occurred in early spring, first in the leaf and afterwards in the flowering stalk. Summer and autumn grass had no activity, although broad red clover was found to be active throughout the year. Whether these oestrogens in British herbage are of any practical significance was investigated by feeding pure oestrogen (hexoestrol) to dairy cattle and young stock. The effect of 5, 15 and 45 mg. per cow per day on milk yield was erratic but there was slight, though inconclusive, evidence of an increase in S.N.F. percentage.

A.S.F.

POULTRY HUSBANDRY

Turkey Production

The decontrol of table poultry prices will, no doubt, lead to an increasing interest in production problems connected with this section of the poultry industry; it is obvious that great improvements in existing methods must take place before table poultry production can recover its pre-war position. One section which seems capable of great development is turkey production. Some interest will therefore attach to three papers on turkey production problems which appeared in the January issue of *Poultry Science*. Asmundson and Moses in a paper entitled " Influence of Length of Day on Reproduction in Turkey Hens " in *Poult. Sci.*, **29**, 34-41, give an account of the effect on production and hatchability of controlled lighting periods of varying lengths. The authors found that production commenced significantly earlier as the length of lighting periods was extended, and that the increased extent of the lighting did not have any consistent effect—advantageous or adverse—on the hatchability of eggs from the birds so treated when compared with unlighted birds.

In the same publication Funk in a contribution " Body Weight and Reproduction in Turkeys ", calls attention to the apparent relationship between certain characteristics. Funk points out that birds of heavier weight show a lower hatchability in all eggs set than smaller birds. The author also maintains that larger birds tend to produce larger eggs, but that egg production and the viability of the poults produced do not appear to have any relationship with body size of the parents.

Some interesting observations are made by Harper in a paper entitled " Body Changes during the Turkey Breeding Season " (*Poult. Sci.*, ibid,

98-103). Harper concludes from his work that the weight of breeding turkeys increases over the first four weeks of the breeding season and then declines. A similar—although less marked—change took place in the breast width changes of the birds, while shank length continued to increase over the same period.

Feeding

The increasing trend towards intensive methods of management has led to some experimentation in mechanized feeding methods, and the general subject is discussed by Bressler, Sprague and Mowery in a contribution " Can Mechanized Methods of Feeding Poultry replace Hand Methods ? ", published by the Pennsylvania Agricultural Experimental Station, No. 1532 (1949). The authors describe the use of an automatically fed mash hopper ; it is pointed out that a considerable amount of labour is saved by the use of this equipment, but stress is laid on the probability that, at present prices, the system would only be economic in very large units. Bressler, one of the co-authors, in another publication from the same station (No. 1533) entitled " Economic Analysis of Labour Saving Methods ", gives an extremely interesting account of the saving of labour achieved by the rearrangement of equipment, the installation of mechanized appliances and the design of the interior fitments.

Further work on the Animal Protein Factor is contained in an article by Sunde, Cravens, Elvehjem and Halpin in *Poult. Sci.*, **29,** 204-7 on an " Unidentified Factor required by Chicks ". The authors describe experiments in which diets containing all vegetable protein received supplements of crystalline B_{12} and also protein supplements of animal origin, such as liver products and fish solubles. The authors conclude from the results of their experiments that the unidentified portion of the animal protein factor leads to an increased growth response in young chicks over and above that achieved by B_{12} supplements alone.

It will be known that dried cow manure contains the animal protein factor ; Miller and Groschke in the *Quarterly Bulletin of the Michigan Agricultural Experimental Station,* 1949-50, **32,** 279-87, give an account of " The Occurrence of Animal Protein Factor in Horse Manure as measured by Chick Growth Response ". The authors point out that horse manure only shows the presence of the animal protein factor after a period of incubation.

A paper by Brisson, Nikolaicyuk and Maw entitled "An Evaluation of Calcium Supplements available for Poultry Feeding in Quebec " published in *Agriculture (Quebec) No.* 4, 1949, **6,** 352-60, gives an account of the choice by poultry of poultry grits of varying size, colour and hardness. The data presented indicate that the most popular choice was the hardest grit, the most insoluble in HC1, and those with particles over 5 mm. in diameter. Grits of dark colour seemed less attractive than those of lighter colour.

An analysis of another aspect of the poultry industry, produced with the intention of achieving economies, is a bulletin with the title " Changes

in Egg Quality" published by the Michigan Agricultural Experimental Station, *Special Bulletin* 361, 1949. The bulletin describes the several stages in the collection, grading and distribution of eggs, points out where losses result and gives suggestions for their reduction and possible elimination.

Further work on the value of Vitamin B_{12} is described by Muskett and Ott, in a paper entitled the "Influence of Crystalline Vitamin B_{12} on Gizzard Erosions in Chicks" (*Poult. Sci.*, 1949, **28**, 850-4). The cause of gizzard erosion is not completely understood. It is not due in any way to an excess of sharp grit but apparently to the absence of some protective nutrient normally supplied to the chicks by the dam via the egg ; in older birds the condition is apparently caused by the absence of the same food factor presumably affecting the production of some bodily secretion. The authors of the paper under discussion found that 2.5 micrograms of vitamin B_{12} per kilogram of a basal diet prevented the condition in chicks from parents so fed, but four times the amount was needed to achieve the same result when the parent birds were given an all-vegetable ration.

R.C.

CROP HUSBANDRY

New Crop Varieties

F. R. Horne (*Journal of the R.A.S.E.*, 1949, 110) has recently stated that to be fully effective the improvement of crops through the use of better varieties involves three stages : (1) the breeding and selection of new varieties and strains ; (2) the testing of new types so that the best can be clearly identified and recommended to farmers either on a national or regional scale ; (3) the propagation of seed stocks of new varieties so that these are similar to the original type.

In France, Belgium, Holland, and some other countries the plant breeder is given a "copyright" on any valuable new variety he may produce, and this enables him to recover his expenses. The intense activity in breeding stiff strawed varieties in France is an example of how the system may work. Horne has summarized the reasons for unsatisfactory seed crops of cereals grown from N.I.A.B. stocks as follows :

	per cent
Impurity due to border effects from adjoining crop	23
Admixture in crop of other cereal crop	23
Admixture in crop of other variety of same cereal	20
Wild onion, wild oat or radish	13
Miscellaneous	21
	100

Sugar Beet

The United States Department of Agriculture during research into the wastage of sugar beets during storage has found that the more the

beets are allowed to dry before storage the more likely they are to rot. This is attributable to the fact that in drying the cell walls crack and make the root more vulnerable to attack by various organisms. There was a striking increase in rotted tissue where beets were dried for a day prior to storage compared with beets stored immediately on lifting.

Potatoes

In Colorado it was found that DCPA compounds when applied to potatoes improved their cooking qualities. Low concentrations increased the specific gravity and the viscosity of potatoes, and resulted in greater whiteness on cooking. In Pennsylvania, where potato rows are wider apart than is common here, calcium cyanamide applied on top of the ridge before emergence of the plants has helped to control weeds ; the use of 2:4D between the ridges has been partially successful.

Kale

In *Marrow Stem and Other Kales* the firm of Cannell and Sons Ltd., Loddon, Norfolk, have produced a handy little guide to the history, analysis, cultivation and uses of these valuable forage plants. Special points are that marrow kale provides more protein per acre than any other root crop, and that its feeding value is greatest at the time of year when pasture has begun to decline in yield and quantity. It is stated that there is usually no gain in dry matter after mid-November and no loss for about 6-8 weeks ; but after early February both dry matter and nitrogen fall off.

Tropical Soils

Those of us who have no experience of tropical conditions are apt to think that the humid tropical forest regions of the world must have rich soils capable of producing heavy arable crops. A very different picture is painted for us by R. L. Pendleton (*Agron. Journ.*, March, 1950, **42**). He says that almost all the plant nutrients in a tropical forest are in the growing trees : organic matter cannot persist long in tropical soil : leaf mould does not develop. When a forest is cut and burned, the plant nutrients are released in soluble form in the ash, and are washed down by the drenching rains into the subsoil quite out of reach of annual crop plants. This accounts for the failure of efforts to grow crops on European lines, including the use of fertilizers. " Forest fallow " methods, and the avoidance of exposure of the soil to sun and rain, are essential to any system of cropping in these wet tropical areas, so that generally held notions as to the unlimited fertility of soils in the tropics are wrong.

D.H.R.
G.E.F.

VEGETABLE CROPS

The following notes on the irrigation of vegetables in California afford an interesting comparison with the article on p. 163 of the Summer

number of this journal. While the detailed recommendations obviously cannot be applied in this country, the broad principles can certainly be translated to our conditions. It should be noted that these papers refer to furrow irrigation and not to artificial rain.

Irrigation and Cultivation of Lettuce, Veihmeyer, F. J. and Holland, A. H. *Calif. Agr. Expt. Sta. Bull.*, 1949, 711.

Soils used for lettuce round Monterey Bay (California) range from sandy to clay loams. The climate is mild. During summer a cool ocean fog blankets the valleys for at least a few hours daily, reducing transpiration and loss of soil moisture. Rainfall is confined to winter and varies from 5 to 30 inches.

Winter lettuce is planted on the flat and is not irrigated.

Summer lettuce is sown in raised beds, two rows per bed. These are irrigated by running water down the furrows for several hours. To germinate the seed the water is held in the furrows until it soaks away into the beds. Two to eight irrigations are performed during the growing period according to the permeability of the soil. Care is taken to prevent water flooding over the beds and causing a crust to form.

The beds and furrows are formed by dragging a sled-like implement over the land. Knife and chisel-shaped cultivators covering several beds are used frequently during growth.

The authors describe nine experiments on commercial holdings. They found that the number of irrigations (once, thrice, and five times) did not affect date of maturity. Yield was unaffected by frequency of irrigation except when the interval was more than 30 days.

Subject to considerable experimental error, they calculated that 6 inches of water (reckoned as inches of rain) were used to germinate the seed, 4-6 inches at the time of thinning, and 2-4 inches afterwards. From determinations of soil moisture, plant-uptake, drainage and evaporation the authors conclude that much of this water is wasted.

The quantity of water required to germinate the seeds depends on the height of the beds. On low-lying patches of imperfectly levelled ground, it is necessary to use higher beds. In one experiment lettuce was grown on low beds adjoining a highbed planting. The low beds were formed merely by running a broad-track tractor over the land. On the low beds 11 inches of water were required for germination compared with 26 inches on the high beds. Both applications were considered more than normal, because of the sandy nature of the soil.

For summer and fall lettuce on normal land the authors recommend 4-6 inches water at sowing, followed by 3-4 inches in each of two later irrigations. They find that soil moisture measurements alone cannot be used to determine when to irrigate.

No relation between irrigation and tipburn or bolting was observed.

Effect of Irrigation on Production of Carrot Seed. MacGillivray, J.H. and Clemente, L. J. *Proc. Amer. Soc. Hort. Sci.*, 1949, **54,** 299.

Experiments in California over three seasons showed that a total of 8-12 inches of irrigation greatly increased yield of carrot seed without affecting either germination capacity or size of seed. It was observed that the roots of carrot seed-plants were taking moisture from the soil down to a depth of 5-6 feet.

Effect of Irrigation on Growth and Yield of Sweet Corn. MacGillivray, J. H. *Proc. Amer. Soc. Hort. Sci.*, 1949, **54,** 330.

The author states that most vegetable crops in the field do not show wilting as a primary symptom of low soil moisture. As moisture supply declines, there is a reduction and finally cessation of growth before wilting occurs. (This observation suggests that the vegetable grower cannot rely on the appearance of the plants in deciding when to irrigate. It is generally agreed that to produce first class vegetables, the crop must be kept growing without check till harvest. By the time there are visible symptoms of water shortage, the plants have stopped growing and irrigation has been delayed too long.) Sweet corn is exceptional in that it transpires and grows so fast that wilting does occur as a primary symptom of water shortage.

In five different experiments it was found that weight and height of mature plants and their yield were all proportional to the amount of water applied (up to 35 inches total). Irrigation decreased the dry weight, sugar and nitrogen percentages of the corn, i.e., the seeds from irrigated plants contained more moisture.

E.J.W.

HERBAGE

Differential Survival of Ladino and Common White Clover encased in Ice. Smith, Dale. *Agron. Journ.*, 1949, **41,** 230-4.

Damage to crops is reported through formation of ice sheets. Such damage varies in extent according to duration of the conditions and temperature. Variation in local field conditions makes it difficult to assess varietal differences in survival under such conditions. This paper describes laboratory experiments comparing the survival of stolons from Ladino and common (Wisconsin) white clover when encased in ice at a non-injurious temperature (−3°C.). Common white clover had a higher survival value than Ladino clover.

The measurement of the carbon dioxide liberated from equal weights of stolons of both clovers showed that the metabolic rate of Ladino is higher during winter dormancy than common white clover. The reduced tolerance of Ladino clover encased in ice as compared with common white clover seems to be associated with its thicker and more fleshy stolons and with the accumulation of higher concentrations of carbon dioxide.

Studies on Growth and Development in *Lolium*. I. Relation of the annual habit to head production under various systems of cutting. Cooper, J. P., and Saeed, S. W. *Journ. Ecology*, 1949, **37**, 233-59.

The relationship between the annual and perennial habit of plants was studied in six species and strains of the genus *Lolium* through their differential responses to systems of cutting as measured by ear production and associated morphological differentiation as expressed by the proportion of leaf to stem. The six species and strains were (*a*) *Lolium rigidum*, Wimmera ryegrass, an annual, (*b*) *Lolium italicum*, Italian ryegrass, a biennial, and four distinct types of *Lolium perenne* consisting of (*c*) Irish commercial ryegrass, a short lived perennial, (*d*) Aberystwyth S.24 ryegrass, (*e*) Aberystwyth S.23 and (*f*) Aberystwyth S.101 ryegrass.

Under a system of *fortnightly* cuts the strains and species could be grouped differently for the periods before and after the normal time of ear emergence. The proportion of stem to leaf in the cuts before ear emergence begins is higher in the early-flowering strains (Wimmera, Irish and S.24 ryegrass) than in the later-flowering S.23 and S.101 ryegrass, with Italian ryegrass occupying an intermediate position. After the normal times of ear emergence the annual and short lived perennials (Italian ryegrass, Wimmera and Irish ryegrass) produced a higher proportion of stem than the more perennial species S.24, S.101 and S.23 ryegrasses.

When cuts are made at *monthly* intervals the pattern of leaf/stem production and grouping of species are similar to the fortnightly cuts, but owing to the longer intervals, stem production is more pronounced.

When the first cut is made at *date of ear emergence* or *at flowering* for the individual species, there is little difference between the stem percentages of the various strains in these particular cuts.

Productivity

In total productivity from spring to autumn under all cutting treatments (with the exception of the fortnightly cuts), Italian ryegrass outyields the other species and strains. High productivity in Italian ryegrass appears to be dependent on lenient cutting up to date of emergence ; in later cuts its capacity for recovery declines. Under all systems of cutting Irish perennial ryegrass is lower in total productivity than any of the selected strains. In spite of differences in ear emergence and flowering date, the bred strains show parallel curves of productivity under all treatments. The total yields obtained from the different systems of cutting confirm the results of many workers in that the highest dry matter yields are obtained under the more lenient systems of cutting and is diminished with increasing frequency of cutting.

The difference between the behaviour of annual and perennial species could be explained in differences which exist between them in the rapidity by which differentiation occurs into reproductive and vegetative parts. In the annual and short lived species, the high proportion of reproductive growth, the rapidity of its formation and its continuance

after the normal flowering period, depletes the food reserves and photosynthetic capacity of the plant to a much greater degree than in the perennial species and strains ; within this group of species and strains there would thus be a negative correlation between persistency and stem or flower production.

Producing Alfalfa and Red Clover Seed in Iowa. Wilsie, C. P. *Agron. Journ.*, 1949, **41**, 12, 545-50.

Assuming satisfactory seedling establishment and survival, seed production is uncertain with red clover and alfalfa. Summer rains may delay the cutting of the first crop for hay until after the optimum time, which, for later seed production, is considered to occur before the full bloom stage. Bright, clear, warm weather conditions at the time of flowering of the second crop favour the activity of pollinating insects so essential for good seed production since lucerne is largely, and red clover almost entirely, cross fertilized primarily by insect pollinators. Unsuitable weather at harvesting time can reduce the crop yield, while too rough handling can cause much shattering and loss of seed.

The most efficient pollinators of red clover and lucerne are bumble bees, and some species of wild bees, but their numbers are too often very small. Honey bee populations can be increased, but their efficiency as pollinators depends on whether they are collecting nectar, when very few flowers are tripped and cross pollinated, or collecting pollen, when they are quite effective. However, honey bees may neglect collecting pollen from red clover and lucerne if more attractive crops are available such as white clover, alsike and sweet clover. Despite the lesser efficiency of the honey bee as a pollinator in comparison with the bumble bee, increasing the concentration of honey bees up to five colonies per acre has had a beneficial effect in increasing seed setting, more particularly in red clover crops.

Insects can be destructive to the developing buds and flowers ; in Iowa these include potato-leaf hoppers, aphids, grasshoppers, alfalfa bugs and several species of *Lygus* bugs. Field experiments showed that in the case of lucerne there was an appreciable increase in seed yield by the destruction of harmful insects through the application of DDT dust at the pre-bloom stage. The increased yields were very much dependent on the weather conditions, while the use of DDT dust did not have a significant effect on the seed yield of the experimental red clover crops.

T.E.W.

NUTRITION OF HORTICULTURAL CROPS

Boron Deficiency

Certain soils in the U.K. are prone to boron deficiency when overlimed and it is assumed that the soil conditions which arise as a consequence of such practice make the boron unavailable to the plant.

Whilst annual crops such as sugar beet, swedes and mangolds are affected, there is little evidence about perennial crops being susceptible or showing a response to applications of boron. Top fruits in many parts of the world are particularly susceptible to the deficiency and some recent results involving application of borax in solid or in spray form are reported here.

The Control of Boron Deficiency. Wade, S. C. *Tasmanian J. of Agric.*, 1949, **20,** 197-200.

In Tasmania, the crops which show signs of boron deficiency are apples, swedes and turnips. In apples the symptoms are found on the fruit. Affected fruit develop brown corky tissue either around the core (" internal cork ") or near the surface (" superficial cork "). When symptoms show near the surface, pits develop on the skin as a result of the affected areas shrinking. In severe cases of " superficial cork " the surface of the fruit becomes badly cracked. Trees with fruit only affected have a normal habit of growth but others more seriously affected develop die back, and produce a weak crop of growths below the bare tops. The most satisfactory method of control is to apply dressings of borax to the soil. A young bearing tree, moderate sized trees and large trees require $\frac{1}{4}$, $\frac{1}{2}$-$\frac{3}{4}$ and 1 lb. respectively. The treatment should be made every three years. Borax should be applied in August and broadcast beneath the extremity of the branches.

A quick response in the first season can be obtained only by spraying the trees with a solution of $2\frac{1}{2}$ lb. of borax in 100 gallons of water. The spray should be supplied shortly after the calyx stage, and used alone rather than with other spray materials.

Soil dressings of borax at the rate of 15-20 lb. per acre give effective control of boron deficiency in roots.

Boron Requirement of Plums. Hansen, C. J. and Proebsting, E. L. *Proc. Amer. Soc. Hort. Sci.*, 1949, **53,** 13-20.

Boron deficiency occurs on European plum (*Prunus domestica*) in California. The Japanese plum (*Prunus salicina*) is unaffected. Symptoms occur only on the fruit. Brown sunken areas which develop in the flesh of the fruit may be in the form of isolated spots or may encompass the whole fruit. Fruits showing symptoms usually colour up early in the season and drop to the ground. In some cases gum pockets may be formed in the flesh of the fruits. Some trees reach full size before showing these symptoms whilst others show them in their first season of fruit production.

Chemical estimates of boron in the leaves and fruits showed that if the boron level in the leaves fell below 25 p.p.m., symptoms in the fruit were always found. On the other hand, fruit picked from a deficient orchard and divided up into affected and seemingly normal specimens, contained 5-7 p.p.m. boron in each case. In a normal orchard the fruit contained 40-50 p.p.m. boron. However, it appeared that the concentration of boron in the fruit carried on trees deficient in

boron, was lower than that in the leaves, but more boron was found in the fruit flesh than in the leaves when the boron level in the tree was high.

Trials carried out to remedy the deficiency showed that the symptoms could be eliminated by applications of borax to the trees in the autumn at the rate of ½ lb. per tree. A single soil application was found effective for several years. Some injury occurred due to an excess of boron in the tissues when borax was used at the rate of 1 lb. per tree.

Effect of Boric Acid Sprays Applied during Bloom upon the Set of Pear Trees. Batje, L. P., Thompson, A. H. *Proc. Amer. Soc. Hort. Sci.*, 1949, **53**, 141-2.

In the north-west of America Anjou pears bloom heavily but fail to set satisfactorily. In the experiments described four limbs on each of 10 trees were chosen. When the blossoms were open, boric acid sprays were applied to three limbs, using concentrations of 5, 25 and 125 p.p.m. of boron. The fourth limb on each tree acted as a control. A count of fruits remaining after the June drop showed that the 125 p.p.m. treatment resulted in a significantly greater fruit set than in the control. It is suggested that boron may influence or correct (*a*) pollen germination and pollen tube growth ; (*b*) the formation of plant auxins ; and (*c*) an incipient or temporary deficiency of boron.

W.P.

FRUIT

Rabbit Damage to Fruit Trees

The protection of fruit trees against rabbit damage is an important and costly item of fruit growing. In this country most reliance is placed on efficient wire-netting fences round the fruit plantations or wire-netting guards round individual trees ; the alternative, a protectant paint, has been generally less reliable, is messy to apply and, under certain conditions, is liable to cause injury. Little or no research on rabbit damage has yet been done in this country, but overseas, especially in Canada and the U.S.A., various workers are attacking the problem, though, of course, their " rabbits " belong to several species all different from our rabbits and hares.

The Western Canadian Society of Horticulture have a Standing Committee on Rodents which presented an interesting report at the 4th Annual Meeting of the Society in 1948. This report, compiled by W. L. Kerr(1), showed that the bush rabbit (snowshoe rabbit or varying hare) was the most important of several rodent pests. The committee considered that all rodents have cycles of abundance and scarcity, and stressed the importance of decreasing their numbers during the low period of their cycle. Extermination in any area, however, seems to be of only temporary benefit owing to migration from other areas.

It is helpful to reduce rough cover for rabbits in the neighbourhood of plantations, and wire-netting fencing, complete with box-traps or

snares set along the runways outside the fences, can provide very effective protection. The simple box-trap described consists of a tent-shaped cage measuring about 36 in. long, 30 in. wide and 30 in. high, with ends and base of wood or metal and sides of wire mesh. The sliding trap door (about 10 in. × 12 in.) fitted in one end is actuated by a pan about 12 in. square hinged to the bottom at the entrance end. The other end of the pan is connected by means of a flexible wire to the trigger, which holds the trap door up. Poisoned baits are used successfully in some parts but as strychnine is the chief chemical used very great care is needed in view of the danger to children, livestock and birds.

Use of Repellents

While the value of a good repellent to protect trees is obvious, many commonly recommended repellents fail because they contain materials, such as linseed oil, creosote, axle grease and crank case oil, that are toxic to plant tissues in varying degrees. In some cases, scalding results, in others foliation is delayed or inhibited, while in others girdling effects are observed. Some repellents appear to be effective when alternative food is available but cease to be effective when hungry rabbits are abundant. It is pointed out that repellents vary in their effectiveness against different varieties of rabbit but two materials are considered promising, the U.S. Fish and Wildlife Service compound 96A, and a rosin-alcohol formula, made by dissolving 2 lb. of rosin in 1 quart of denatured alcohol. A sample of 96A has been received at East Malling and preliminary tests are encouraging ; it is a mixture of copper carbonate, copper sulphate and lime sulphur, with rosin and asphalt as adhesives, and is thinned with ethylene dichloride. A good repellent should be easily applied by brush or spray and remain effective throughout the dormant season, besides being non-toxic to the trees. This report contains a useful bibliography.

Wrapping of Trees

Somewhat similar ground is covered in a paper by T. J. Talbert(²) based on experience in the state of Missouri. In addition to the normal wire-mesh guards for individual trees he describes the use of hard-ware cloth, old newspapers and sacking torn in strips 6-8 inches wide. Special wood-veneer wrappers, specially prepared paper and building paper may also be used effectively. Newspapers are used in pieces 18-24 inches square, two thicknesses being applied to each tree. The paper, which is allowed to come down into the soil, is wrapped round snugly and tied with string at the top, centre and bottom. Tarred paper is not advised as it can cause injury. Sacking is applied as a spiral, wrapped closely round the stem, beginning a few inches below ground level and continuing up to a height of 18-20 inches. One tie at the top is sufficient. The wraps can be left on for several years without doing injury to the trunks. Harmful insects have not been observed under the sacking and the removal of the wraps at different seasons of the year has not led to any injury due to exposure to sunlight and rain.

Regarding repellent washes, Talbert points out that many are ineffective or injurious under certain conditions and recommends lead arsenate added to whitewash, soapsuds or diluted lime sulphur at the rate of 1 lb. to 10 gallons. This mixture can be sprayed on or, when prepared in a more concentrated form, can be applied by brush, and there is no risk of injury. Where rabbits are not very plentiful, the simple precaution of starting pruning soon after leaf-fall and leaving the prunings on the ground, may result in the rabbits gnawing the prunings in preference to the tree trunks. Talbert advises the early treatment of injured trees by applying grafting wax over the injured area to assist healing and by bridge-grafting where necessary.

Repellents for use on leafy plants are reported on by D. W. Haynes([3]) of Michigan, working with cotton tail rabbits in pen and field trials. Of 26 materials tested, nicotine sulphate (40 per cent) (at the rate of ½ teaspoon to 1 quart of water used as a spray), nicotine bentonite (at 2 teaspoons per quart also used as a spray), tobacco dust, and equal parts of red pepper and flour, ranked highest in protective ability, with tobacco dust showing the best lasting qualities. None of these materials was very persistent in rain, but they might be worth trying on strawberries or raspberries where rabbits are troublesome in this country. Bordeaux spray, wettable sulphur, and rosin emulsion, amongst others, proved less effective, and those showing no action or injury to the plants included alum, sulphur, naphthelene, cuprous oxide and lead arsenate.

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H.B.S.M.

FLOWERS AND SOILLESS CULTURE

Comparative Costs

The problem in soilless cultivation on which information is most urgently required by growers is that of the comparative costs of the various methods in relation to normal methods of cultivation in soil. Little reliable data are even yet available but a recent American publication ([1]) is of interest. Carnations were grown in two beds, each 36 feet by 4 feet, one containing soil and the other gravel fed with nutrient solution by the sub-irrigation technique. Costs of installation were $72.00 for the soil and $252.10 for the gravel beds. Detailed costs for materials and labour were kept for the first year from the time of filling the beds, charging all labour at $1.00 per hour. The total cost for the soil bed was $88.45 and that for the sub-irrigation bed was $68.83. Comparative production was 2,247 flowers in soil (sold for $273.17) and 2,690 flowers

in gravel (sold for $321.13). The differences in production, however, may not have been significant, as sodium selenate was applied to both beds to control below-ground infestation with red spider and this could be washed out of the gravel at the first sign of injury but not from the soil. Ignoring capital depreciation, operating costs were 28 per cent higher in soil than in gravel, and returns were 35 per cent higher in gravel than in soil.

Growing Mediums

A good deal of interest has also centred about the choice of a suitable growing medium for both the sand-culture and the sub-irrigation system. Experience at Reading University with two different sands, one a medium sand of fairly even grade and the other a coarser sand containing larger and finer particles showed no difference in the resulting tomato crop. A grower in Lancashire has had excellent results with a very fine seashore sand while growers in Cornwall get equally good results in coarse grit from china clay deposits. Results reported from America([2]) with Vermiculite used for carnations grown by sub-irrigation show this to be a satisfactory medium. At Reading, gravel has proved satisfactory for carnations, but for tomatoes crushed clinker has given better results than gravel.

Systemic Insecticides

Soilless cultivation methods offer a good means of experimental work on systemic insecticides absorbed by the roots, since exact dosages can be given and the uptake measured much more precisely than with soil. A paper by Beach ([3]) on the use of sodium selenate in the solution to control red spider infestation on carnations is of interest. Various concentrations of the chemical were added to the nutrient solution, varying from eight parts to four parts per million weekly. Good control of red spider was achieved at all concentrations but plant growth was progressively more stunted as the ratio of selenium to sulphur in the solution was narrowed. Even the smallest application was too much as far as maintenance of quality of the cut flowers was concerned. Smaller applications would seem to hold out promise of success.

The Effect of Warm Water Applications to Greenhouse Roses. Pfahl, P. B., Orr, H. P. and Laurie, A. *Proc. Amer. Soc. Hort. Sci.*, 1949, **53**, 489-91.

Experiments were carried out throughout the winter months on roses grown in V-bottom ground benches and flat bottom raised benches, using water from the mains at an average temperature of 46°F. and also water heated by steam injection to 70°F. and 80°F. The temperature records showed that the beds watered with warm water cooled rapidly, while those with cold water warmed up equally quickly, all beds attaining the air temperature of the house within eight hours. No differences in numbers of flowers per plant or in stem length were found.

The results bear out the conclusions of the John Innes Horticultural Institution with regard to the use of cold water on a variety of pot plants.

R.H.S.

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GLASSHOUSE CROPS

Mushroom Research Station, Yaxley, Peterborough. Report for the years 1946-1948 (*contd. from N.A.A.S. Quarterly Review No.* 8.)

Experiment No. 3. This experiment was arranged to compare three levels of nitrogen, supplied as dried blood, and three levels of superphosphate, with a straw compost. Half of the composts had all the phosphates added at the start; in the other half, part of it was added when the compost was shaken out for filling. The results show that the later addition of phosphate caused earlier cropping, and increased the numbers of mushrooms and total yield, but that increased phosphate applied at the start of composting not only depressed the numbers and total yield, but shortened the cropping period. Raising the nitrogen (from 110 lb. dried blood per ton of dry straw to 410 lb.) increased the yield from 0.54 lb. per sq. ft. to 0.85 lb., and gave earlier and more prolonged cropping.

Experiment No. 4. This was to compare nitro-chalk (inorganic) with dried blood (organic) as sole source of nitrogen, combined with three levels of potash, supplied as potassium sulphate. The temperature of the composts containing dried blood was higher than that of the composts with nitro-chalk, but low potash levels gave a higher temperature. The conclusions were that dried blood was greatly superior to nitro-chalk as the source of nitrogen, and the requirement of potassium varied with the source of nitrogen used, dried blood giving the best results with low and nitro-chalk with high potassium.

Experiment No. 5. Dried blood is the main and most expensive constituent of the synthetic compost in its present form, and in this experiment, two mixtures of dried blood and nitro-chalk were used in an attempt to reduce the cost of the synthetic compost. At the same time, supplements in the form of sugar beet tailings (2 cwt. per ton of straw) and castor bean meal (56 lb.) were compared. The results from this experiment are particularly interesting in that sugar beet tailings made no difference to the 75 per cent blood-25 per cent nitro-chalk composts, but raised the yield from the 75 per cent nitro-chalk-25 per cent blood composts to equal that obtained from the former. The yields from the high dried-blood mixture were superior to those from the high nitro-chalk mixture, and castor bean meal raised the yield.

Experiment No. 6. For a number of years, researches have been carried out on the effect of growth substances on the growth of mushrooms, and the belief among mushroom growers that manure from stallions gives heavier crops than that from geldings is old-established. At Yaxley a large number of substances have been tried on a small scale by spraying on to the compost before casing, and the materials which have given the most notable results to date are calcium pantothenate, riboflavin, phenoxyacetic acid and stilboestrol. Tray experiment No. 6 was planned to test the effect of peak heating, the addition of growth substances, and the use of casing soil without the usual additions of sand and lime.

Experiment No. 7 was designed to study the effect of filling trays with compost at successive turns. (The normal procedure at Yaxley is to fill at the fifth turn.) At the same time a proportion of the trays was treated with a 1 per cent solution of beef extract, and with stilboestrol. The conclusions were that fruiting began first on fifth turn compost ; fourth turn compost came into crop last, but it supplied more food material to support the growth of mushrooms than did third turn compost. This difference was wiped out by beef extract, which brought all composts into crop 10 to 20 days earlier. Other interesting variations brought out by the addition of beef extract are described.

Experiment No. 8. The objects here were : (i) To assess the progress made with synthetic composts by comparing the latest product with good horse manure, and with a typical proprietary activator ; (ii) To ascertain whether a mixture of M.R.A. synthetic compost and horse manure was better than either or both of them individually ; and (iii) Whether fermentation with horse manure had any effect which could not be obtained merely by its presence in the finished compost. Owing to an attack of plaster mould the crops as a whole were unsatisfactory, but the difference in the final yield between M.R.A. synthetic compost and mixtures of M.R.A. and horse manure composts mixed early in composting or at filling, was not significant. There was no indication that the presence of horse manure during composting has any particular beneficial effect. The compost mixed at the time of filling came into crop first ; the horse manure produced poor crops, probably because of over composting and the proprietary compost was very low in nitrogen and produced a poor crop.

Other experiments described in this report include the effect of peak-heating on the crop, the growth rate of mushrooms and the analysis of composts by the Chemistry Department.

The Microbiology Department reports on the technique adopted for examining the numerous fungi found in composts and casing soil, and the effect of temperature on the growth of these, and of bacteria and protozoa on straw in a saturated atmosphere. A list of fungi either parasitic on mushrooms, or as invaders of the beds, and fungi of varying or doubtful status in the compost or soil during the period under review, is also given.

Cheshunt Experimental and Research Station. Annual Report 1946

Investigations of problems connected with mushroom culture were started here in 1936, when a timber mushroom shed fitted with shelves was erected. At the outset, investigations were concerned entirely with casing soil, but compost treatment was later dealt with. The results are summarized as follows :

1. Mushroom diseases can be introduced in soil used for casing beds, and it is advisable to sterilize casing soil by means of heat.
2. Thorough cleaning and sterilization of the house, shelves, etc., between crops is an essential part of disease and pest control.
3. For casing purposes, heavy clay or silt soils free from plant roots are the most suitable.
4. In some cases the crop can be increased by mixing an appropriate amount of moist peat with the casing soil before application.
5. The addition of gypsum to the manure at the first turning almost invariably increases the yield.
6. Addition of castor seed meal at the first turn has increased the yield.
7. Air temperatures of 60-65° F. are probably the optimum for mushroom cultivation.

Experiments with Soils used for casing Beds of the Cultivated Mushroom. Pizer and Leaver. *Ann. appl. Biol.*, 1947, **35**, 34-44.

Experiments on the influence of the casing soil on the cropping of mushroom beds are described. Results of a survey of cropping at thirty-nine mushroom farms show that when compost and cultural conditions are suitable, mushroom production may be largely determined by the casing soil. These are classified into four grades, and a method of assessing the cropping potentialities of soils is described. It is suggested that chemical substances or specific surfaces in soils may promote cropping, but that close contact with air is necessary for them to be effective. Conclusions are that direct trial is the only reliable method of assessing the value of a material for casing.

E.S.

MYCOLOGY

TOMATO DISEASES

Tomato Root Rot (*Didymella lycopersici*)

This disease appeared to be one of the most serious causes of loss of tomato plants during and immediately after the war years and is still by no means negligible. A number of publications indicate its importance and discuss various aspects of it. Hickman(1) carried out investigations during the years 1941 to 1945 in the outdoor tomato crop in the Evesham area and demonstrated the possibility of seed-borne infection and the serious losses arising from infection during propagation of the plants. There seemed to be little risk under normally good horticultural

rotation of the disease being carried over in the soil from year to year but the fungus survived on canes stored from one season to the next. He was unable to detect in what manner the fungus survived on the canes. During this work Hickman showed that there were two strains of fungus one of which attacked both fruit and stems and the other which attacked fruit but was only slightly pathogenic towards stems. He has also recorded(2) the occurrence of the perithecial stage of this fungus in the field.

A number of papers by workers at Cheshunt Research Station have been devoted to this disease. Confirmation of the presence of two different strains of the fungus was obtained by Mrs. Sheard(3) who found that the fungus isolated from outdoor fruit did not readily attack them under glass. She also showed that the disease could be spread by air-borne spores and that these spores could be trapped in greenhouses and in the open several months after the crop had been removed. Formaldehyde vapour and sulphurdioxide both destroyed these air-borne spores. Mrs. Sheard(3) and W. H. Read(4) tested the effect of a number of fungicides and thought that malachite green and mercury compounds showed most promise in killing the spores of the fungus. In later experiments (Sheard(5) and Read(6)) ethyl mercury phosphate appeared to be the most effective fungicide at inhibiting spore germination and gave some promise when used as a soil fungicide. Unfortunately, when larger scale greenhouse trials of this chemical were made there was insufficient disease development to yield any useful information. Read(6) was not able to obtain any effective control of wound infections by spraying the tomato stems with any mercurial fungicide or with polyethylene polysulphide, whether the spraying was made before or after infection took place. The effect of manurial treatment on outbreaks of stem rot has also been studied. In experiments made by Williams in 1946(7) excessive nitrogenous manuring appeared to increase the susceptibility of the plant to infection and also to increase the severity of the disease, but in the following season(8) no relation could be found between the appearance of the disease and any manurial treatment.

Verticillium Wilt

F. M. Roberts(9) has investigated some of the factors influencing infection of tomato by the fungus *Verticillium albo-atrum*. The plants became more susceptible to infection when manured with nitrogenous fertilizers. Phosphates did not appear to have any effect on the development of the disease but lack of potash tended to encourage it. If steam sterilized soil became contaminated with the fungus immediately after steaming, a large proportion of the tomatoes planted in the soil became infected. If there was a delay of 17 days or longer before the steamed soil became contaminated, it was no more favourable to the development of the disease than was unsterilized soil.

It was also shown that the fungus spread more rapidly from an infected plant to the roots of neighbouring healthy plants if the infected plant

was killed. In later experiments ([10]) a wide variation in potash manuring had no influence on susceptibility of tomato plants to *Verticillium* when there was an adequate supply of phosphates and nitrogen. If plants received adequate fertilizers, severe defoliation caused them to become very resistant to infection. The author thought this effect was due to reduction in the carbohydrate content of the plant.

P. H. Williams([11]) also further investigated Verticillium Wilt disease of tomatoes. He found that when tomato plants were kept under conditions of high temperature and high moisture, development of the disease due to *Verticillium albo-atrum* was checked but that the disease caused by *Verticillium dahliae* was little influenced by these conditions. In experiments carried out in two years([11]) ([12]) he found that high soil moisture did not materially affect the development of the disease. In tomato plots receiving different manurial treatments the disease appeared first in plots receiving complete artificial and stable manure and was worst in that plot and the plot receiving complete artificials only. The disease was not severe in plots in which either nitrogen, phosphate or potash was omitted. In the plots receiving no fertilizer, symptoms were more severe than in the deficient plots but less severe in those receiving complete manurial treatment. Soil treatment with 8-hydroxyquinoline sulphate had no control over the wilt caused either by *Verticillium albo-atrum* or *Verticillium dahliae*.

H.E.C.

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ENTOMOLOGY

The Apple Blossom Weevil. Dicker, G. H. L. *Ann. Rep. East Malling Res. Sta.*, 1948, **49.**

This short paper is designed to draw the attention of growers and others to certain changes in recommendations for the control of this pest. While it is common knowledge that DDT is an excellent control, there are many who may not be aware of the easiest and most effective ways of applying that information.

Experiments have shown that DDT remains effective against the weevil for four weeks when mixed with an oil spray at a concentration of 0.05 per cent; at double the strength, protection was extended to 6-8 weeks.

Where growers are using tar oil washes during the dormant period, a similar method may be practised. The tar oil spraying may be delayed until February and DDT added at a concentration of 0.1 per cent (i.e., 5 lb. of the 20 per cent wettable powder per 100 gallons of wash). A good control of the weevil will then be obtained.

Isolated plantations may not need to be sprayed against Apple Blossom Weevil more than once in 4 or 5 years. Less isolated plantations may need spraying once in 3 years. It is, however, essential to spray the whole of the apples on the holding in the same year.

The Predator Aspect of the Fruit Tree Red Spider Problem. Collyer, E. *Ann. Rep. East Malling Res. Sta.*, 1948-1949.

This work was carried out in Essex and a full account is given of the predators on Red Spider. A list is included comprising over 40 insects, and some mites and spiders, which were found to be predators on red spider in Essex during the years 1944-48.

Certain of the insects were found to be of marked importance as compared with the remainder; these were the black-kneed capsid, two species of anthocorid bug, a small black coccinellid beetle (" ladybird " family) and one of the small species of rove beetle. A small species of lacewing (*Conwentzia*) was also of considerable importance.

The effect of sprays on these very important checks has been studied, it now being recognized that DDT has been responsible for much of the increase in red spider, by reason of the reduction in the numbers of predators. It has been found that winter oil sprays kill hibernating adults of many of the predators and that summer washes of derris, nicotine, azobenzene or lime sulphur kill many of the nymphs of the black-kneed capsid, particularly if applied after mid-June.

It is suggested that no DDT sprays should be applied after the " green cluster " stage, owing to the fact that this material may have a residual effect up to a period of eight weeks. To keep to this rule would do much to avoid a serious build-up of red spider.

L.N.S.

VIROLOGY

The Spatial Distribution of Insect-borne Plant-virus Disease. Gregory, P. H., and Read, D. R. *Ann. appl. Biol.*, 1949, **36,** 475-82.

Various workers have proposed formulae to express the spatial distribution of insect-borne diseases. All the published data examined, as well as the Rothamsted data for the spread of rugose mosaic and leaf-roll from point sources in potato crops, were equally well-fitted by the simple empirical expression $\log I = a + bx$ as by more complex expressions. (I = number of infective punctures at a distance x from the source after a given time; a and b are constants for any one given set of field conditions.) It is suggested that distances should always be given in metres, in order to give comparable results from one investigation to another. In the analysis of data on rugose mosaic and leaf-roll in different years, it is shown that a and b vary independently.

Overwintering of Aphids, especially *Myzus persicae* (Sulz.) in Root Clamps. Broadbent, L., Cornford, C. E., Hull R., and Tinsley, T. W. *Ann. appl. Biol.*, 1949, **36,** 513-24.

Mangold clamps in many districts of the British Isles were found to provide overwintering sites for *Myzus persicae* (Sulz.), *Hypermyzus staphileae* (Koch) and *Aulacorthum solani* (Kalt.). After a severe winter, when other means of overwintering are few, clamps may be the most important source of *Myzus persicae*. Only *Myzus ascalonicus* Doncaster was found in swede clamps.

Factors affecting the infestation of clamped mangolds by *M. persicae* were the number of aphids on the crop when lifted, the methods of topping and clamping the roots, and the temperature in the clamp. *M. persicae* was introduced on the leaves, and close topping was often an efficient means of control. Close topping did not control *Hypermyzus staphileae*; normally, this aphid does not seem to be a root-feeding species, but with artificially colonized mangolds it fed on both exposed roots and foliage. It is not known how this species enters the clamps. The temperature in the clamps was influenced by that of the outside air and the type of cover, but changes were long-term and did not reflect diurnal variations in external air temperature. Straw, covered with soil, was the best form of cover. In addition to harbouring *Myzus persicae*, mangold clamps are also important sources of sugar-beet yellows virus.

Internal Browning Disease of Tomato. Holmes, F. O. *Abstr.* in *Phytopath*, 1950, **40,** 13.

Outbreaks of internal browning disease of tomato in Middlesex County, New Jersey, showed close association between mosaic plantains (*Plantago* spp.) and first affected tomatoes. Both plantains and tomatoes were found to contain a series of similar but unusual strains of tobacco mosaic virus. This suggested that infection of the tomatoes had arisen from the diseased weeds. Experimental control was achieved by locating

tomato fields at a distance from infected plantains and by use of mosaic-resistant lines of tomato.

Effect of Tobacco Mosaic Virus on Yield of Glasshouse and Field-grown Tomatoes. Alexander, L. J. *Phytopath.*, 1950, **40,** 1.

Two experiments were conducted to determine by how much the tobacco mosaic virus reduces the yield of tomatoes. Plants in the unstaked control plot remained free of virus, but 13.2 per cent of plants in the staked plot were infected when the first fruit was picked. Thereafter, no further effort was made to limit spread of the virus. Yields from plants in staked plots were reduced 0.5, 7.2, 8.1 and 11.0 per cent, and those from plants in unstaked plots were reduced 17.0, 10.0, 21.8 and 26.4 per cent, respectively, for the July 16, June 18, May 29 and May 10 dates of inoculation.

For the same dates of inoculation, the respective decrease in number per plant from staked plants was 5.4, 11.3, 10.2 and 17.9, and for plants in unstaked plots, 1.9, 0.2, 4.4 and 11.8. In a second experiment conducted in a commercial glasshouse, the yield in terms of pounds per plant was 11.80, 12.96, 13.20 and 13.40 respectively, from plants inoculated January 18, February 23, March 29, and April 12. In terms of money the increase would be considerably greater.

A Cucumber Virus Strain with a Wide Leguminous Host Range. Hagedorn, D. J. *Abstr.* in *Phytopath.*, 1950, **40,** 11.

During a 1948 study of viruses affecting canning peas in Wisconsin, an apparently new strain of cucumber virus I was isolated on two occasions from diseased pea plants found near Madison. Symptoms on artificially inoculated peas in the greenhouse included coarse leaf mottle, plant stunt, mild stem necrosis, plant wilt and premature death. On cucumber, tobacco, and zinnia, symptoms typical of cucumber virus I appeared. Host range experiments indicated that the new cucumber strain was capable of infecting the following legumes : *Melilotus officinalis*, *Phaseolus vulgaris*, *Pisum sativum*, *Soja max.*, *Trifolium hybridum*, *T. incarnatum*, *T. pratense*, *T. repens*, *Vicia faba*, and *Vigna sinensis*.

This appears to be a considerably wider leguminous host range than has been previously reported for the cucumber virus.

(The possibility of a similar development in this country is worth bearing in mind in view of the widespread occurrence of the cucumber mosaic virus in all kinds of plants.)

Chrysanthemum Stunt. Brierley, P., and Smith, F. F. *Abstr.* in *Phytopath*, 1949, **39,** 502.

Chrysanthemum Stunt, first recognized in 1945, became generally recognized among greenhouse plants in the United States and Canada in 1946. Affected plants are abnormally small, and leaf and flower size

is reduced, the former being pale green and the latter bleached. Transmission of the virus was achieved by grafting, sap-inoculation and by means of the aphis *Rhopalosiphum rufomaculatum*. The minimum period for the development of symptom expression after grafting is about 3½ months but the usual period is 7-10 months or in the second flowering after inoculation. Control measures should include selection of sound plants during two successive flowering periods, aphid extermination, and careful handling. (It is not clear yet whether the disease of stunt is the same as the disease prevalent in chrysanthemums in this country which is caused by an aphis-transmitted virus of the cucumber mosaic type.)

A Note on Viruses affecting Ornamental Plants

Reference was made in this REVIEW (No. 7, p. 130) to a new virus affecting *Tropaeolum* in Cambridge. A second, apparently undescribed virus, has now been observed on the same host plant. This virus is very similar in its reactions on solanaceous plants to the cabbage black ringspot virus, but efforts to transmit it to brassicas have so far failed.

An apparently new virus has been isolated from imported lilies. This virus is of the ringspot type and is transmissible to certain solanaceous hosts. The insect vector has not yet been identified.

K.M.S.

INSECTICIDES AND FUNGICIDES

In the United States a foodstuff is legally considered adulterated if it contains any substance injurious to health, or if it contains any added deleterious substance not required in its production or capable of being avoided in good processing. It is this law which regulates decisions on the presence of residue of pest control chemicals used either on the growing crop or in storage, and it follows that if these chemicals are hazardous to health, the food stuff would be legally regarded as adulterated. But in American law it is recognized that the use of insecticides and fungicides may be necessary and the Food and Drug Administration is charged with the duty of prescribing limits or tolerances, the food being adulterated only if these tolerances are exceeded. For the establishment of these tolerances the Administrator is required to hear, in public, the evidence of all interested parties ; a record of the evidence is made on which the Administrator bases his decisions.

Up to the end of last year, only one such hearing under this particular Act had been made dealing directly with pest control chemicals, as a result of which the tolerance for fluorine remaining as residue on peas and apples was fixed at 7 milligrams per kilogram of fruit. This ruling was subsequently rendered ineffective, for the Court of Appeals construed the regulation to be restricted in application to fluorine in its elemental state. (Was the Court of Appeals unaware that elementary fluorine is gaseous at ordinary temperatures?) Hence, the present

hearing will cover not only the fluorine insecticides, but also a list of some 150 other chemicals embracing most present day pest control and growth-regulating substances. It is likely that the Administrator's decisions will have a profound influence on the development of pest control methods, not only in the United States, for this is the first occasion on which the difficult problems of the hazards of modern insecticides and fungicides in fruit and vegetable production will be discussed in all these aspects.

The hearing began on January 17, 1950, and is likely to continue for many months. The proceedings so far have been summarized in the succeeding monthly issues of *Agricultural Chemicals* since February 1950. The evidence which has so far been given is that of those officers of the Department of Agriculture and the various States who are concerned in research or advisory work on pest and disease control. A powerful case has been made for the necessity of the use of chemicals in present-day crop production. The evidence of representatives of growers' organizations and of the manufacturers of pest control substances will follow.

The first witness, Dr. F. C. Bishop of the U.S.D.A., asserted that fruit and vegetables would be unmarketable without the use of insecticides, whether the standard was set by consumers or the inspectors of the Food and Drug Administration. He referred to the increase in food production which can be directly credited to the use of insecticides during and since the war and he pointed out, that although nearly one billion pounds of insecticide are used annually in the United States, there is no substantial evidence of any adverse effect on public health. Dr. Porter, of the same department, stated that, in the absence of insect control, much of the fruit reaching the market would be unfit for human consumption. U.S.D.A. entomologists from Washington, Indiana, South Carolina, California and other States, stated the main uses of the insecticides and fungicides for the different fruit and vegetable crops, and reported on the results of residue studies under the varied climatic conditions of the various States. From the published summaries it is already evident that the full proceedings will provide a vast accumulation of up-to-date phytopathological, entomological and chemical data on pest and disease control in the United States.

Nomenclature

Reference has already been made in this Review (1949, **2,** 92) to the need for short, everyday names for chemicals which find use in crop protection and of which the chemical names are unwieldy. The implication of this reference that some names such as lindane have already been adopted internationally, is incorrect, for no decisions have yet been agreed by the British Standards Institute which has recently set up a committee to deal with this nomenclature. Moreover, the trade name " Gammexane " is now used by the proprietors to describe products containing gamma BHC either in a crude or purified form.

H.M.

Response of Legumes to Boron

The problem of boron deficiency in the soils of the eastern states of the U.S.A. has been under investigation for well over a decade. The early recognition that it was responsible for alfalfa "yellows" stimulated research in the coastal plains where, both on the "cotton" soils and on marginal lands, many failures of legumes had been experienced.

The work carried out on the Main Experimental Station at Auburn, Alabama, has served to throw much light on the many aspects of this problem, which may well be applicable to other parts of the world, including the British Isles. The soil on which most of the work was done is described as a Norfolk loamy sand—one of the so-called Red and Yellow Podsolic Soils covering extensive areas in the south-eastern plains. In so far as the deficiency is obviously very marked and the effects on crop growth very well defined, the results of the trials and the observations made carry weight and conviction.

The legumes tested include, among others, alfalfa, crimson clover, red clover and hairy vetch which are classed as susceptible to boron deficiency, and winter peas, blue lupin, soy bean and alyce clover which are more or less non-susceptible. Alfalfa which gave a response in 12 out of 13 trials carried out at various centres, produced on the average 58 per cent more hay where borax was applied, representing an increase of 16 cwt. of hay per acre per annum for the addition of 20 to 30 lb. per acre of material at the time of seeding.

With the trifoliums, the outstanding effect was on the rate of seed production. In 10 trials in Alabama, light dressings of borax produced an average increase of 259 lb. of seed per acre, or 244 per cent. In some instances this increase in seed production was obtained where there was no apparent effect on vegetative growth, though usually this was observable and averaged about 30 per cent.

At the Station Farm at Auburn, small field plot experiments to measure the effect of boron on crimson clover seed production were laid down in 1941 and the results for seven years beginning in 1942 are available. The treated plots received 10 lb. per acre of borax in the autumn of 1941, and 15 lb. per acre in 1942, 1943 and 1944. Dolomitic and calcitic limestone at rates from about 13 to 70 cwt. per acre with and without borax were used and all treatments were in triplicate. The Boron content of the plants of the 1942 crops showed that those from the untreated plots (limed and unlimed) averaged about 10 p.p.m. as against 20 p.p.m. from the treated plots. The limestone does not appear to have had any material effect on this uptake, though it reduced slightly the amount of water-soluble boron found in the soil at that time. The figures for the average of the untreated and treated plots were .051 and .117 p.p.m. The yields of seed for that year averaged 64 and 1055 lb. per acre for the two series of plots and for the seven-year period 1942-1948 they were 59 and 462 lb. per acre.

In 1942, i.e., one year after the application of the lime, the base status of the soil in the various plots and its buffer capacity may be gauged from the following table of *p*H values :

No lime	5.87
13 cwt. per acre dolomitic lime	6.83
36 „ „ „ „	7.20
72 „ „ „ „	7.69
13 „ „ calcitic lime	7.37
26 „ „ „ „	7.67

With soy bean and alyce clover the crop yields support the statement that 10 lb. per acre of borax on these same plots had a toxic effect, which was neutralized to some extent by the application of lime, the dolomitic being more effective in this direction than the calcitic.

If, in any particular soil, the availability of boron is a function (among several other factors) of the lime status, it would seem that, with lucerne and possibly some of the trifoliums, it might become a problem of some difficulty to strike a nice balance in the matter of *p*H to produce optimum conditions for crop production. It may be pertinent to ask if the need for lime for lucerne is as great as many agronomists would have us believe. It is true that one seldom hears of failures associated with overliming, but on the other hand, many excellent and long-lived stands have been grown on moderately acid soils. Similarly, attention might profitably be directed to those soils, usually light and not well buffered, where clovers grown for seed may be yielding poor crops but at the same time showing no other recognizable symptoms of deficiency.

A.B.
W.M.D.

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MACHINERY

Haymaking Methods

Success in haymaking should be measured by the quality of the product rather than by the speed of work, or the amount of labour needed for the job. Nevertheless, success in achieving a product of high quality often depends directly on the speed with which the various stages of the work can be done, using a limited labour force ; so studies of the time and labour employed on these operations are of considerable interest to many farmers.

In a study carried out in Gloucestershire in 1948, Stubbs (*Time and Labour on the Farm*, H.M. Stationery Office, 1949) recorded the following performances in terms of man-hours per ton required for getting the

hay stored, from the stage when it was fit to haul :

Method	Labour *Man-hours per ton*
Sweep and stationary baler	(i) 5.5 (ii) 3.8
Hay loader and stack	5.2
Sweep and stack	(i) 3.5 (ii) 2.5 (iii) 1.8
Pick-up baler	(i) 2.9 (ii) 2.8 (iii) 2.6 (iv) 2.6 (v) 2.5 (vi) 2.4

Emphasizing the importance of hay quality, it is argued that a saving of 15s. to 20s. a ton on the cost of making is insignificant compared with the potential value of the product. The figure mentioned of £3 a ton difference in value between good and poor hay must be reckoned a conservative estimate.

A N.I.A.E. Report, *A Study of Haymaking Methods*, gives the results of an investigation by the Farm Mechanization Enquiry on farms in Scotland, Yorkshire and Wiltshire, carried out in the summer of 1947. Methods studied included piking and cocking on the northern farms, as well as the system of collecting direct from windrows generally practised in the south. Of 12 fields surveyed, detailed observations were made on all the work done from cutting to stacking in 10 cases. A description is given of the methods employed, with dates of the various operations and approximate yields.

The 1947 haymaking season was an exceptionally good one, but in spite of this, the hay in Scotland was cut on average 7½ days before piking, and stayed in the pikes for a further fortnight. In Wiltshire, the average time that the hay lay in swath and windrow before stacking or baling was 12 days, and this lengthy period in a good season shows that there is much room for improvement in haymaking techniques. The hay put into pikes or cocks averaged about 30 per cent moisture content, while the average moisture content at stacking was only 16 per cent. There should be encouragement in this report for those who are interested in the development of barn hay drying.

The advantage of the self-tying pick-up baler with regard to labour requirements is marked. The report concludes that further information is required to determine whether piking is essential in Scotland, or whether mechanized methods can be more widely applied. More information is needed on moisture contents at which hay can be successfully baled direct from the field.

Average labour requirements, excluding cutting, turning and side-raking, were as follows :

Method	Labour *Man-hours per ton*
Piked, swept and stacked (Scotland)	7.9
Cocked, carted and stacked (Yorks)	3.1
Cocked, swept and stacked (Yorks)	3.9
Swept and stacked (Yorks)	3.1
Swept and stacked (Wilts)	3.3
Carted and stacked (Wilts)	4.0
Piked and baled (Scotland)	5.6
Swept and baled (Yorks)	3.0
Pick-up baler (fully automatic) and bale loader (Wilts)	1.4

Bulletin 855 of the Cornell University Agricultural Experiment Station, 1949, *Labour used and Cost of Harvesting Hay in New York State*, deals with haymaking methods on typical commercial family farms in New York State. The report covers the years 1944 and 1945, when labour was particularly scarce owing to the war. An attempt was made to discover why certain methods were more successful on one group of farms than on another, but no significant conclusions on this point are to be found in the Report. The survey method was employed, reports being obtained from 412 farms soon after the conclusion of haymaking. The following summary, extracted from a number of detailed tables, shows approximately (*a*) the average hay acreage handled, (*b*) the labour force available, and (*c*) the labour requirement in man-hours per ton on farms using the main types of equipment that are of interest in Britain :

Method	(*a*) Av. Acres Hay	(*b*) Av. No. of Workers *per Farm*	(*c*) Av. Man-hours per ton* for Baling, Hauling and Storing
Hand-pitching to waggon	25-30	1.7	4.2
Tractor buckrake† ...	40-45	1.9	1.9
Hayloader and waggon...	45-50	2.2	2.9
Hayloader and motor truck	55-60	2.8	3.0
1-man pick-up baler ...	60-65	3.0	2.1
Field chopper (forage harvester)	70	3.6	1.5

* Adjusted to 2,240 lb.

† A large rear-mounted sweep which can be raised clear of the ground by power hoist.

Hand-pitching methods and buckrakes were common on strictly family farms, while balers and forage harvesters were used on farms having hired labour. On average, cutting accounted for 20 per cent of the cost of harvesting, raking for 12 per cent, turning 5 per cent, and baling, hauling and storing upwards of 60 per cent. The average cost of labour was half the total of labour and equipment items. With one-man balers and field choppers, however, labour accounted for only one-quarter of the cost. The lowest total cost was achieved with buckrakes.

Among interesting conclusions are (1) hand-pitching can have no place on even small commercial farms in New York State, (2) the buckrake method—relatively new to this state—can be recommended for hauls of not more than 0.3 miles, and (3) one-man balers, owing to the expense of the machine, were reckoned economic only if more than 100 acres of hay were to be harvested.

A U.S.D.A. publication, *A Handbook of Standard Performance Rates for Haying Equipment commonly used in the North-East*, gives rates of

work achieved by efficient operators in various conditions. The standard situation assumes a rectangular field of 4 acres, with length twice the breadth, on gently rolling land free from obstructions, and located $\frac{1}{4}$ mile from the homestead. The standard crop is 4,000 lb. per acre of mixed hay, and it is assumed that all equipment is in good condition.

Typical examples of standard rates taken from the handbook are as follows :

Kind of Equipment	*acres per hour per outfit*
7 ft. cut P.T.O. driven tractor mower	2.6
6 ft. cut horse mower	1.4
4-bar tractor side-rake	4.7
3-bar 2-horse side-rake	2.7
	tons per hour per outfit*
Automatic pick-up baler	5.4
Tractor drawn hayloader (2 men and 1 boy)	3.8
Truck and hayloader (1 man and 1 boy)	3.0
Buckrake on truck chassis (900 lb. loads)	3.6
Bale loader with truck (2 men and 1 boy)	6.2
Forage harvester and trailer (1 tractor and 2 men) ...	3.2

* Adjusted to 2,240 lb.

Hints given for improving efficiency include increasing the size of loads of loose hay to about 4,500 lb. where practicable ; improving farm roads to permit high transport speeds (up to 10 m.p.h.) ; choice of tractors with five or six gears so that optimum speed can be used ; keeping crops and areas of work in as large blocks as possible ; and employment of a " double-loading " method when using buckrakes to increase load size and reduce empty running time in the field.

C.C.

PROVINCIAL NOTES

HOT-WATER TREATMENT OF BROCCOLI SEED

J. H. Bant, A. Beaumont and I. F. Storey

Yorks and Lancs Province

Many rhubarb growers in the Leeds-Wakefield area are also producers in the early summer of high quality broccoli. Locally saved seed is used, and many of these strains of broccoli have been in the same family for several generations. Seed is saved each year from the best plants selected at cutting time. The conditions under which the seed is saved are not ideal and weather conditions during the later stages of ripening are often most unfavourable.

One of the worst diseases affecting the crop in this area is Canker (*Phoma lingam* (Fr.) Desm.) and serious losses of the order of 50-80 per cent have occurred in some seasons. The seed appears to be the main source of infection. A broccoli crop will normally be followed by rhubarb which occupies the ground for another 2-3 years. Care is taken to select ground for a seed bed that has not had a brassica crop for several years. By these means the risk of soil borne infection is reduced to a minimum. Canker has also been found attacking savoys, brussels sprouts and spring cabbages.

The investigations of Millard (1945) showed that the hot water treatment of seed (122°F. for 25 minutes) recommended by Clayton (1927) gave an excellent control of the disease. During the seasons 1937-46 hot-water treatment of seed was carried out on behalf of growers by the Department of Agriculture at Leeds University. With the setting up of the N.A.A.S., it became necessary to make other arrangements. A service was accordingly organized by the Horticultural Department of the West Riding A.E.C., and with our assistance treatment of seed was begun in the winter of 1946-47. That the service continues to be appreciated by the growers is shown by the following figures :

Season	*No. of growers*	*Weight of seed*
		lb.
1946-47	11	65
1947-48	20	448
1948-49	29	221
1949-50	39	612

The grower pays a fee of 5s. per lb. for the first 5 lb. and 2s. 6d. per lb. for the remainder.

The apparatus used is the bath originally devised for the hot-water treatment of bulbs. The seed is placed in hessian sacks which are only half filled as it is essential for the water to circulate freely through the bulk of seed. About 5-7 lb. of seed is placed in each sack and not more than twelve sacks are treated at a time. Before the treatment is carried

out, a trial test is run on a small sample of the seed. The germination capacity of both treated and untreated samples is determined and the results of this trial test are sent to the grower before treatment of the main bulk of seed is carried out. If there is a serious reduction in germination, the growers' permission is obtained before proceeding to treat the bulk. The drying of the seed after treatment takes about a week in a warm room and requires a good deal of space as the seed is spread out on blotting paper in wooden trays.

Hot-water treatment of the seed does reduce the germination capacity and care has to be taken to keep this to a minimum. During the progress of the work, several problems have arisen and information has been obtained as to the effect of the treatment on the seed and the efficiency of the treatment in controlling canker.

Effect of Treatment on Germination Capacity

The effect of seed treatment on the germination capacity of samples of seed submitted during the last four years is given in Table 1. Seed more than one year old is not included :

Table 1

Effect of Hot-Water Treatment on the Germination Capacity of Broccoli Seed

Year of harvest of seed	*No. of samples*	*Av. percentage germination of untreated seed*	*Av. percentage reduction due to H.W.T.*
1946	16	66	17
1947	33	92	4
1948	46	85	10
1949	53	89	6

The quality of the seed varies from year to year. The dry summer of 1947 was an exceptionally good year for seed saving and this is shown in the high germination capacity of the seed. The quality of the seed is also reflected in the effect that the hot-water treatment has on the germination capacity. A well ripened, well harvested sample suffers less than one produced in poor condition. The reduction in germination capacity is in fact closely related to the rainfall during August and September. In the four seasons given in the Table, the rainfall at Wakefield was 7.70, 1.37, 4.87, 3.33 in. respectively.

The majority of the seed is not cleaned by modern machinery and contains much light seed that would not be present in a commercial sample. Much crop debris is also present in some samples.

In the early stages of the work, seed was considered to be suitable for treatment if the germination capacity was over 60 per cent. This was later found to be unreliable. The three samples of seed whose germination capacity was reduced by more than 40 per cent had initial germination capacity of 71, 81 and 71 per cent respectively. The most severe reduction is usually met with in the latest maturing strains and these figures serve to show the need for a trial test before the bulk of seed is treated. It is, however, better to sow seed brought to a low germination capacity by heat treatment than to run the risk of losing a crop with canker.

Time of Treatment

Many of the growers save seed in one year to sow over a period of several years. Tests were carried out to determine whether it was best to treat all the seed in the year of harvest or when required for sowing. In Table 2 the effect of treating seed in the year of harvest and after intervals of one year or two years is compared :

Table 2

Effect of Hot-Water Treatment on Broccoli Seed of Varying Age. Germination percentage of Seed Tested in December, 1948

Year of harvest	*No. of samples*	*Untreated*	*Hot Water Treated*		
			at harvest	*after 1 year*	*after 2 years*
1946	3	60	75	55	48
1947	10	86	84	46	—

The best time for treatment of seed is the year of harvest and it is better to save treated seed than to treat it just before sowing.

Effect of Treatment on Longevity of Seed

Treated seed has been tested for germination capacity up to three years after treatment. The results obtained using three samples treated in December 1944 are given in Table 3. An untreated portion of Sample C was also available for comparison.

Table 3

Effect of Hot Water Treatment on Longevity of the Seed

Sample	*Before Treatment*	*Percentage Germination after Treatment*			
	Dec. 1944	*Dec. 1944*	*Dec. 1945*	*July 1946*	*Nov. 1947*
A Treated December 1944	93	89	87	—	62
B ,, ,, ,,	88	69	70	—	26
C ,, ,, ,,	87	67	65	53	5
C Untreated	87	—	—	52	2

Hot-water seed treatment has no serious effect on the keeping quality of seed. This is also shown in Table 2 where seed treated at the time of harvest in 1946 and kept for two years had as good a germination capacity as the untreated seed.

Effect of Double Treatment

Within recent years commercial seed firms have started treating seed by the hot-water method. There is a risk that samples of seed may be submitted for treatment which have already been treated once. The effect of double treatment was tested in July 1949 on five samples of seed treated for the first time in 1947 and on five treated in 1948.

Table 4

Effect of Double Treatment on Germination Capacity

Year of first Treatment	*No. of Samples*	*Reduction in percentage germination due to second Treatment*
1947	5	6
1948	5	4

The effect of the double treatment is clearly not cumulative. There is thus very little risk in submitting seed to a second treatment.

Efficiency of the Hot-Water Treatment

The control of the canker appears to have been at least 99 per cent effective. The odd diseased plant may be found in most fields and it is rare to find more where the plants have been raised from treated seed. Many fields of broccoli grown from treated seed have been examined and in the few instances where the disease has occurred to any extent soil infection has been clearly indicated. For example, at the end of 1948 the crop in a field at Wakefield grown from treated seed showed 7 per cent of canker on the part of the field which had just carried a diseased crop of broccoli. The part of the field following rhubarb was free from the disease. In another instance the seed bed was placed alongside a badly diseased broccoli crop and the land itself had carried a spring cabbage crop previously.

Another outbreak of canker in which about 20 per cent of the plants were affected was recorded in a stock of seed treated for 15 minutes instead of the usual 25 minutes. This was done in order to minimize the reduction in the germination capacity. Where the reduction in germination is severe, the time of treatment may be reduced to 20 minutes but the efficiency of the treatment is impaired to a slight extent.

Acknowledgments. The hot-water treatment service was initiated by F. G. Smith, Horticultural Officer to the West Riding A.E.C. at the time and acknowledgment is made to him and to his successor, H. W. Sayer, for their interest and co-operation.

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